Reconstructing Past Climate and Glacier Changes in the Teton Range, WY from Lake Sediments

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I. Introduction

In this study, we analyze lake sediments from Grand Teton National Park, Wyoming, to interpret past climate events and the corresponding glacial changes. We focus specifically on the timing of glacial retreat following the last ("Pinedale") glaciation and the transition from glacial to non-glacial sediment in Lake Solitude.

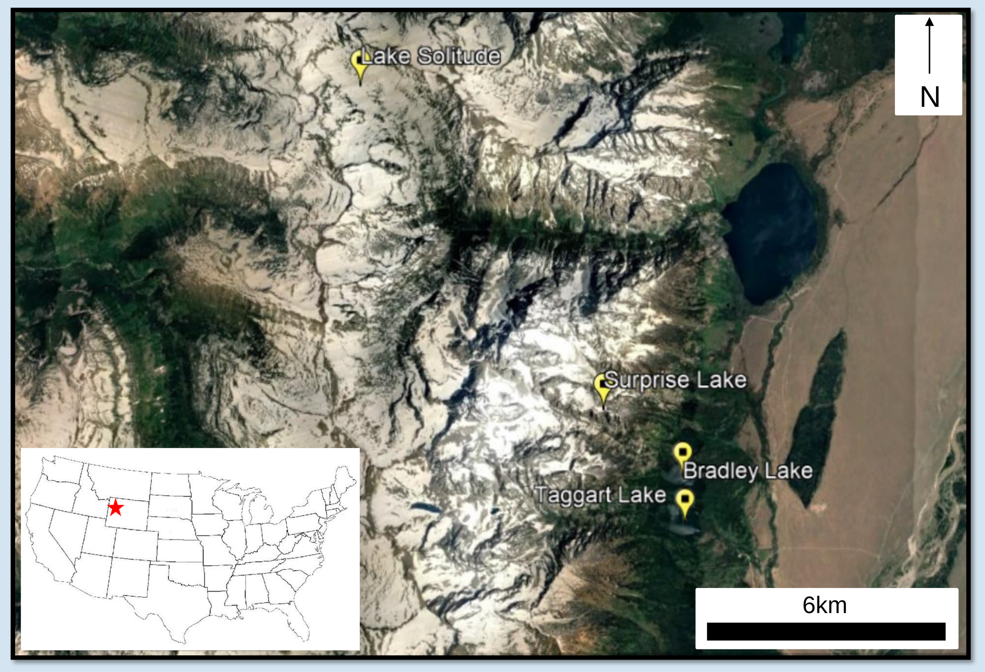

Figure 1. Satellite image of Lake Solitude (red box), Bradley Lake, Taggart Lake, and Surprise Lake.

Here we show:

- A detailed sediment record for the timing and extent of glacial retreat following the Pinedale glaciation
- The transition from glacial to non-glacial sediment in Lake Solitude is defined by changes in physical parameters and organic content that are preserved in the lake sediment
- Alpine glaciers are highly sensitive to changes in climate, serving as valuable paleoclimate indicators

Importance: Earth is currently undergoing rapid change, including increasing atmospheric temperatures, dryer conditions, and retreating glaciers (Larsen et. al., 2016). Geologic records of past climate are crucial in understanding contemporary climate changes and for projecting future changes.

II. Geologic Setting

Figure 2. Satellite image of Cascade Canyon shows the location of Lake Solitude at the head of the canyon.

The eastern side of the Teton Mountain Range contains a series of valleys and lakes that formed in glacially carved basins, last occupied during the Pinedale glaciation 30,000-15,000 years ago (Love et. al., 2003). This study focuses on Lake Solitude (43.7926°, 110.8448°), a non-glacial lake located at the head of the north fork of Cascade Canyon, and Taggart Lake and Bradley Lake, low elevation lakes located at the mouth of the valley.

III. Methods

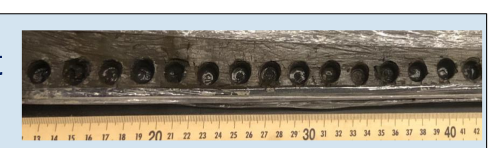

Figure 3. Image of core sampled at every other cm.

The transition from glacial to non-glacial sediment can be observed through physical and geochemical parameters. Glacial sediment is expected to be comparatively denser, contain less organic material, and have higher magnetic susceptibility values relative to non-glacial sediment. The analyses were as follows:

- Sediment cores collected from Lake Solitude, Spring 2020
- Sediment cores sampled at 2cm increments and picked for organic material
- Samples weighed for wet bulk density(g/cc)
- Samples dried and weighed for dry bulk density(g/cc)
- Cores measured for magnetic susceptibility at continuous 1-cm intervals
- Samples incinerated at 550ºC for four hours to determine weight percent loss of organic material (Loss on Ignition: LOI%)

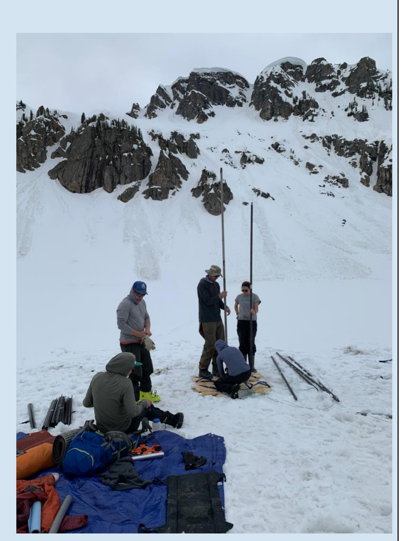

Figure 4. Field team collecting sediment cores, Spring 2020.

IV. Results: Lake Solitude

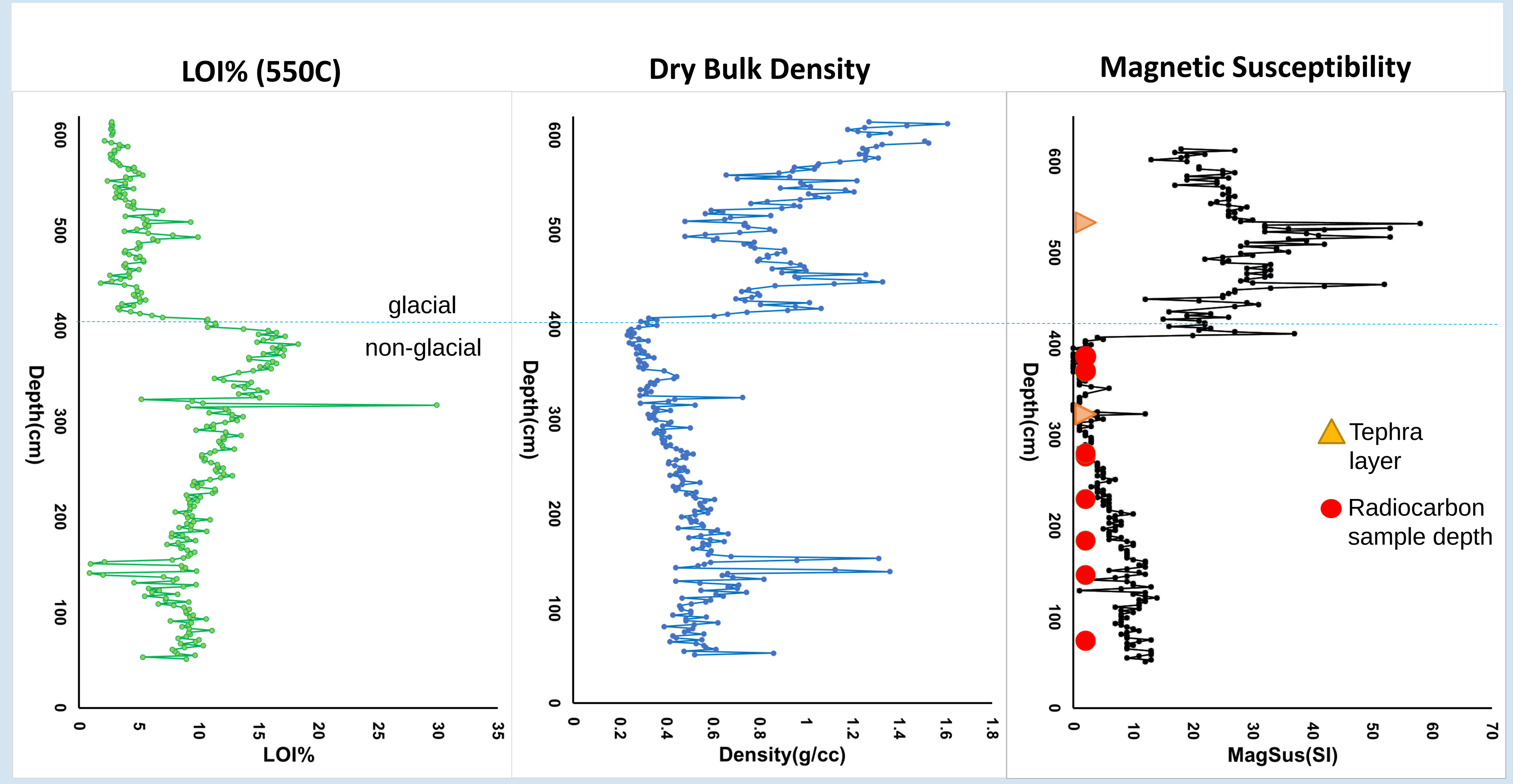

Figure 5. The transition from glacial to non-glacial sediment is marked in blue and is characterized by an increase in % organic material, a decrease in dry bulk density, and a decrease in magnetic susceptibility.

Lake Solitude proxy data shows a sharp transition from glacial to non-glacial sediment.

Glacial Sediment characteristics:

- LOI% approximate: 0-5%
- Dry Bulk Density: 0.5-1.6g/cc
- Magnetic Susceptibility: ~15-60

Non-glacial Sediment characteristics:

- LOI% approximate: 5-20%
- Dry Bulk Density: .2-1.2g/cc
- Magnetic Susceptibility: ~0-15

Results: Taggart Lake and Bradley Lake

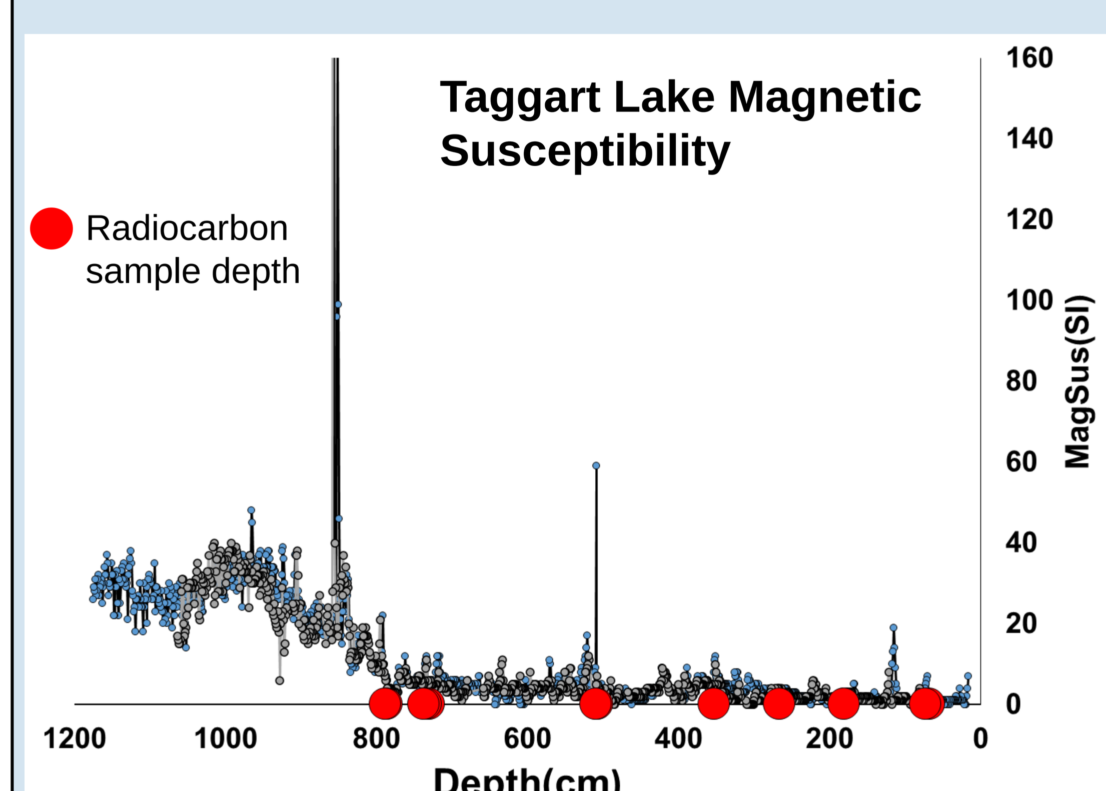

Figure 6. Magnetic Susceptibility for Taggart Lake shows two distinct peaks corresponding to volcanic ash deposits. Low magnetic susceptibility values represent organic rich non-glacial sediment. The transition from glacial to non-glacial sediment is seen in the decrease in magnetic susceptibility at ~900cm depth.

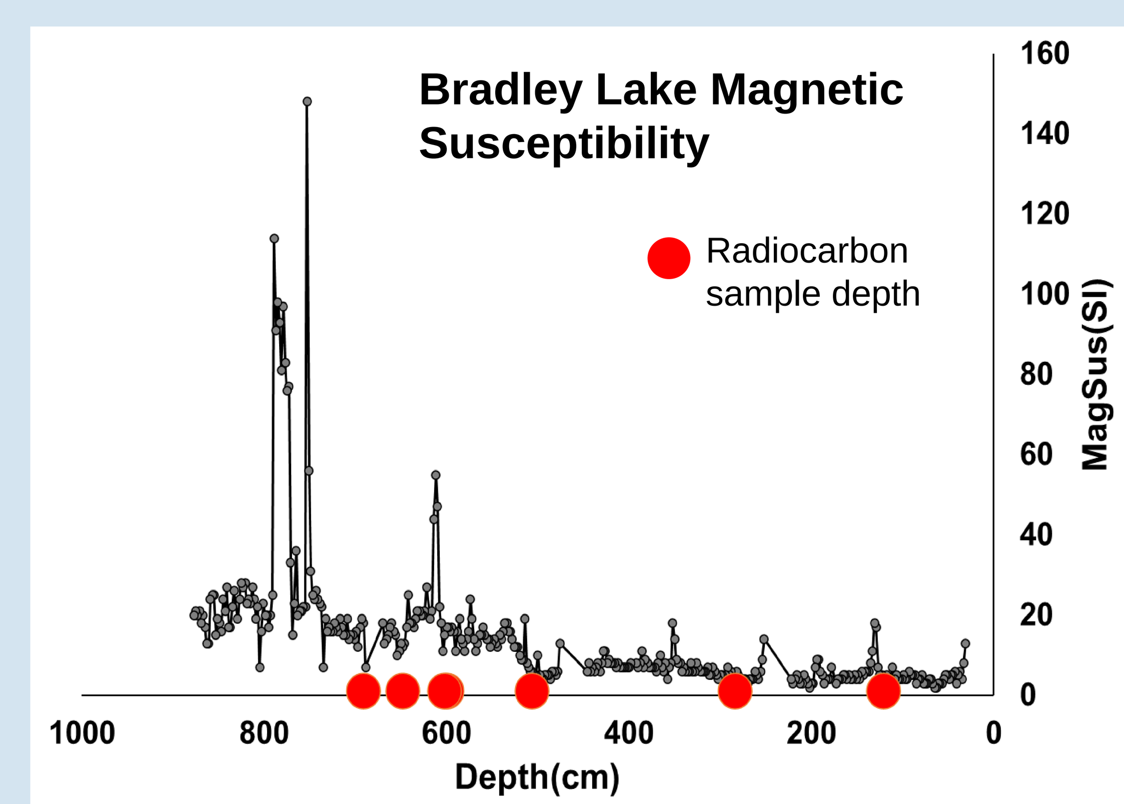

Figure 7. Magnetic Susceptibility for Bradley Lake shows significant peaks at a depth of ~800cm, corresponding to a volcanic ash deposit.

VI. Ongoing Research: Geochronology

While the transition between glacial and non-glacial sediment is clearly visible, the exact timing of deglaciation is still unknown. In order to produce an age model of the Pinedale Glacier retreat, we will use Accelerator Mass Spectrometry radiocarbon (AMS14C) dating.

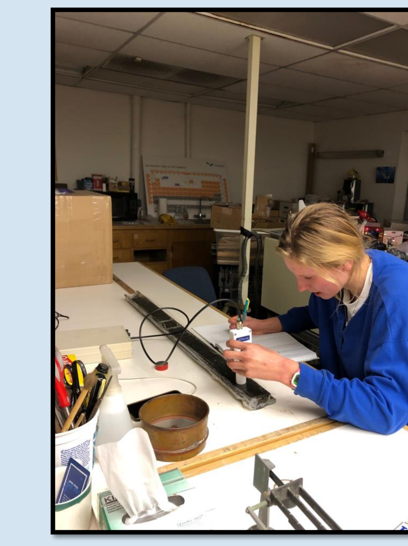

Figure 8. Measuring magnetic susceptibility with Bartington MS2 sensor at Scripps Institute of Oceanography.

During the sampling process, the Lake Solitude, Taggart Lake, and Bradley Lake cores were picked for organic material including woody fragments, conifer needles, and plant macrofossils. The organic samples will be combusted, graphitized and measured for age at UC Irvine. Additionally, the age model will be supported by tephrochronology. Based off visible observations and magnetic susceptibility data, there are 2 tephra deposits recorded in the Teton lake sediment: Mt. Mazama (~7.6 ka) and Glacier Peak (~13.6 ka) (Larsen et. al., 2016). Samples of the tephra layers will be geochemically characterized and added to the age model.

VII. Summary

1.) The Pinedale Glacial retreat through Cascade Canyon is observable in Lake Solitude sediment transitions in % organic material, dry bulk density, and magnetic susceptibility

2.) The inclusion of tephra layers (likely Mt. Mazama and Glacier Peak) reflect glacier retreat by the time of the eruptions

3.) The transition to non-glacial sediment reflects the shift from late Pleistocene conditions to early Holocene climate conditions

4.) % organic material decrease after the transition to non-glacial sediment reflects an increase in summer insolation, which is characteristic of early Holocene climate conditions

Acknowledgments

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References

Larsen, Darren J., Matthew S. Finkenbinder, Mark B. Abbott, and Adam R. Ofstun. "Deglaciation and postglacial environmental changes in the Teton Mountain Range recorded at Jenny Lake, Grand Teton National Park, WY." Quaternary Science Reviews 138 (2016): 62-75.

Love, J.D., et al., 2003. Creation of the Teton Landscape, a Geological Chronicle of Jackson Hole and the Teton Range. Grand Teton Natural History Association, Moose, Wyoming, p. 132